DOCUMENT RESUME

ED 433 178 SE 058 322

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TITLE Science Autobiographies: What Do They Tell Us about Preservice Elementary Teachers' Attitudes towards Science and Science Teaching?
PUB DATE 1996-04-02
NOTE 32p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (St. Louis, MO, April 2, 1996).
PUB TYPE Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Autobiographies; Elementary Education; *Hands on Science; Higher Education; *Preservice Teachers; Reflective Teaching; *Science Instruction; Scientific Principles; Self Concept; *Teacher Attitudes; *Teacher Background; Teacher Characteristics; Teacher Student Relationship

ABSTRACT

This paper reports on a study that examined the effects of formative experiences on the attitudes of preservice elementary teachers towards science and science teaching. Students in the science sequence of an elementary teacher preparation program wrote autobiographical essays about their experiences in science. These essays (n=56) were analyzed for patterns relating to experiences in the elementary, middle school and high school years, as well as non-formal and collegiate experiences. The influence of other people and preservice elementary teachers' representations of science instruction were also examined. The analysis shows the importance of hands-on experiences and the importance of teachers' attitudes toward science across all grade levels in influencing positive attitudes towards science. The analysis also shows that negative attitudes towards science can be partially attributable to poor interactions with teachers and the content driven nature of school science. This study suggests that negative attitudes can be improved by providing relevant hands-on and reflective experiences in science in a teacher preparation program. (Contains 32 references.) (Author/WRM)

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Science Autobiographies: What Do They Tell Us about Preservice Elementary Teachers' Attitudes towards Science and Science Teaching?

by
Valerie Talsma

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SCIENCE AUTOBIOGRAPHIES: WHAT DO THEY TELL US ABOUT PRESERVICE ELEMENTARY TEACHERS' ATTITUDES TOWARDS SCIENCE AND SCIENCE TEACHING?

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Abstract

This study examined the effects of formative experiences on the attitudes of preservice elementary teachers (PETs) towards science and science teaching. Students in the science sequence of a elementary teacher preparation program wrote autobiographical essays about their experiences in science. These essays (n=56) were analyzed for patterns relating to experiences in the elementary, middle school and high school years as well as non-formal and collegiate experiences. The influence of other people and PETs representations of science instruction were also examined. The analysis shows the importance of hands-on experiences and the importance of teacher's attitudes towards science across all grade levels in influencing positive attitudes towards science. The analysis also shows that negative attitudes can be partially attributable to interactions with teachers and the content driven nature of school science. The findings also indicate that negative attitudes can be improved by providing relevant hands-on and reflective experiences in science in a teacher preparation program.

Keywords:

Preservice teacher education, elementary school teachers, teacher attitudes, science education, autobiographies

A paper presented at NARST Annual Meeting
April 2, 1996 - St. Louis, MO

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Introduction

A variety of factors appear to influence the teaching of science in the elementary school. Several factors which have received attention from researchers are the effectiveness of various instructional strategies, the content and pedagogical-content knowledge of the teacher, preservice elementary teachers' preparation to teach science, and attitudes of inservice and preservice elementary teachers (PETs) about science and science teaching. This paper looks at one of these factors: PETs attitudes about science and science teaching. Teachers' attitudes toward science and science teaching can have important instructional consequences including how much classroom time is devoted to science instruction (Shrigley, 1974a; Earl & Winkeljohn, 1977; Manning et. al., 1982), the relative emphases on content and process (Duschl, 1983), and how teachers construe the nature of science (Lederman, 1992). Shrigley (1974b) found that teachers that do not like science are more likely to produce students that do not like science. Pedersen and McCurdy (1992, p. 141) go so far as to claim that poor attitudes toward teaching science in the elementary schools is an ever increasing problem.

Several studies have looked at various predictors of Preservice Elementary Teachers' (PETs') attitudes towards science and science teaching, including age and religious preference (Schwirian, 1969), ACT and C-Base Science scores (Bitner, 1993), number of high school and college science classes (Zeitler, 1984; Bitner, 1993), college transcripts (Schwirian, 1969; Young & Kellogg, 1993; Bitner, 1993), type of undergraduate institution attended (Schwirian, 1969), and science locus of control (Haury, 1989). Of Schwirian's (1969) eight independent variables, age was associated with the greatest attitudinal differences with younger teachers expressing the more positive attitudes toward science. She also found a positive association between the amount of college science experience and science understanding. In contrast, Shrigley (1974b) found a low correlation between science knowledge and teachers' attitudes toward science. Lucas and Dooley (1982) claim that negative attitudes toward science among teachers maybe traced back to the individual's own experiences at school (p. 805) but do not provide support for that claim.

Many of the previous studies on PETs' attitudes about science and teaching science revolve around attitude surveys such as the Bratt Attitude Test (Westerback, 1982), and the Science Attitude Scale (Shrigley, 1974a; Lucas & Dooley, 1982; Shrigley & Koballa, 1984; revised by Thompson & Shrigley,

1986).[1] Only one study (Young & Kellogg, 1993) has taken a more qualitative approach, an exploration of PETs' recall of formative science experiences through descriptive essays.

Attitudes are influenced by the complex interaction of interests, values, understandings, life experiences, and perceived abilities, but little is known about the direct or indirect effects on attitudes toward science and science teaching. What experiences lead PETs to define themselves as non-science types? What experiences lead PETs to view science in a positive light? One finding in Young and Kellogg's (1993) study is that PETs were strongly influenced by their teachers in elementary and secondary education. Many of the PETs in their study described these early experiences as ones that caused them to define themselves as non-science types or helped them pursue interests in physical and biological sciences.

A common strategy in professional development programs to change teachers attitudes toward science and to improve science instruction at the elementary level has been to change, restructure, or increase science course requirements during teacher preparation (Stefanich & Kelsey, 1989; Harty & et.al., 1991; Tolman & Campbell, 1991). Based on these efforts to improve PETs attitudes towards science, there is more to developing teachers' attitudes toward teaching science than simply providing them with more content. Unpacking PETs' formative experiences may lend further insights to their attitude formation and suggest interventions that can be enacted during their professional development.

This Study

The purpose of this study was to look at what PETs tell us about their experiences with science and science teaching and how these experiences might play out in their attitudes toward teaching science as expressed through science autobiographies. Specifically, how do experiences in the elementary, middle, and high school years as well as non-formal and collegiate experiences influence the attitudes of PET's to science and science teaching? How do PETs characterize their science instruction? What is the perceived role of significant others (teachers, parents, peers, etc.) in attitude development? How do earlier experiences contribute to existing attitudes toward science as expressed in PETs definitions of science and visions of science instruction?

This study is based upon the notion that effectiveness in teaching elementary school science is to some extent a function of the teacher's attitudes toward science, which is in itself a consequence of significant personal and professional experiences. By examining PET's science-autobiographies we may gain insight into how experiences in the elementary, middle, and high school years as well as non-formal and collegiate experiences influence the attitudes of PET's to science and science teaching. References to specific episodes and the roles of significant others (teachers, parents, peers, etc.) were of particular interest in trying to answer the question of how their earlier experiences contribute toward existing attitudes toward science as expressed in PETs definitions of science and visions of science instruction. In addition, references to collegiate impacts will have implications for the types of experiences in science that need to be provided in an effective professional development program.

Methods

Study Situation

The students that participated in this study are Preservice Elementary Teachers (PETs) at a medium size mid-western university. The elementary science program of this former Normal School has won a National Seience Teachers Association (NSTA) Search for Excellence in Science Education Award. The elementary science program requires PETs to take four courses (12 semester hours) in science courses that integrate both science content and methods for teaching science in the elementary classroom. These courses are specifically designed for PETs, in contrast to many preparation programs which require PETs to take general science courses or one general science teaching methods course (Tolman & Campbell, 1991). The course in which this study was conducted, Biology for Elementary Teachers (ESC 303), is the fourth in the sequence of semester long courses for the group science minor that also includes introductory courses in physics (PHY 100), chemistry (CHM 101), and earth science (GES 202). Wylo's (1993) study of this elementary science program found that of the students in the four science courses, 88% were female and that the average age of the students was 22.8 years. Her sample was predominantly upperclassmen with over 75% juniors, seniors, or graduates. Students in the biology course (ESC 303) are typically seniors in their last semester before student teaching. Many have teaching minors in "group science" and have completed the other three courses in the sequence although those courses are not pre-requisites. (See Wylo, 1993 for a more complete

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1 Other instruments include the Self-Estimated Proficiency in Science (SEPS), Moore's Science Teaching Attitude Scales (STAS), Revised Science Attitude Scale for Preservice Teachers (Thompson & Shrigley, 1986; Bitner, 1994).

description of this elementary science program).

ESC 303 has an enrollment limit of twenty students per section and the sections are usually filled to capacity with a waiting list. Two tenured faculty and three instructors teach the approximately 300 students who pass through the sequence annually. ESC 303 is taught with a strong emphasis on hands-on learning in the life sciences and provides the PETs' with their first formal opportunity to teach science to small groups of elementary students in the schools.

The data for this study was collected from three sections of ESC 303 during the 1994-1995 academic year. Fifty six of the sixty enrolled students consented to participate in this study: forty-four (79%) women (four African-American, three Hispanic) and twelve men. Fifty four of the students (96%) were senior class undergraduates and two (one male, one female) were graduate students seeking teaching certification. Thirty two (57%) of the participants indicated a major or minor in the group sciences and 68% had taken at least one of the other elementary science courses, and 60% had competed all three. Ten (18%) of the students identified themselves as "second career students" and there is more than a two decade span of ages among the participants.

Data Source

This study is based upon an analysis of a student writing assignment. As their first assignment in ESC 303, the PETs were asked to write their science autobiographies. The class discussion preceding the assignment was based on the notion of scientific literacy called for in such documents as *Project 2061: Science for All American* (AAAS, 1989; Rutherford, & Ahlgren, 1990) and *Michigan Essential Goals and Objectives for Science Education*, (MDOE, 1991). Students were also encouraged to start sharing their early childhood experiences in class. The prompt for the ungraded assignment asks the PETs, as a step toward becoming science teachers, to look at their education "through the lens of science" as they describe their science background derived from instruction in elementary, secondary, and post-secondary education. They were also asked to used the exercise to reflect on non-formal experiences in science, their beliefs about science and scientists, and how they perceived the teaching of science. (See Appendix 1 for the assignment text.).

This essay was the primary source of information. Demographic data on the sample was obtain from course enrollment forms.

Analysis

The student essays (n=56) were entered into the database as computer text documents. Once class section of data (n=17) was used for the initial analysis. The dimensions of the content analysis were determined using a method of emerging categorization (Zeitler, 1984; Young & Kellogg, 1993) around the education divisions of elementary (K-5), middle-school/junior high (6-8), high school (9-12), college and non-formal domains. Categories such as science background and interest, the mention of specific experiences in science or feelings about science, the influence of other people (i.e. teachers, peers, parents, etc.), definitions of science and visions science teaching were derived from the essays.

Once the categories of analysis were established, the essays were mined for descriptive passages pertinent to the categories and to the questions of this study. These passages were extracted from the text documents and grouped under the various categories. All the passages within a category were read several times to identify patterns of similarities or themes and unique experiences. The passages were then coded using a plus-minus-zero (+/–/0) designation to reflect whether the experience was related in a positive, negative, or neutral manner. After the initial data analysis of the first 17 autobiographies was completed, the emerging categories and themes were checked and verified by analyzing the essays from the remaining two class sections (n=39).

Once all of the text excerpts were placed into categories and coded, they were counted to estimate the prevalence of the experiences. I use the phrase "estimate of prevalence" because essays varied in completeness and the types of memories recounted. Specific quotes are used to illustrate the different categories of experiences or perceptions. Quotes are attributed to individual PETs but all names have been changed to protect the subjects' anonymity.

Results

The fifty-six science-autobiographical essays varied in length from 88 to 1063 words with an average length of 496 words. In content they varied from a vague overview of the impression of science on the authors' lives to detailed descriptions of specific episodes. In their writing the PETs generally revealed if they were "science seekers" who enrolled in a variety of science courses and/or participated in science experiences outside of school, "science avoiders" who only experienced science as a requirement, or somewhere in between.

In the repeated readings of the essays, five themes emerged that help to

reveal why students hold particular attitudes towards science : 1.) the domination of text-based science education in the schooling of these PETs and its association with negative experiences of science; 2) the strong impression that hands-on experiences had in the recall of science experiences across all levels of schooling and its generally positive association; 3). recalled interactions with other individuals (teachers, parents, peers, etc.) in modeling attitudes and providing opportunities to experience science, these could be either positive or negative, 4). the important role of non-formal experiences in science in helping to frame positive attitudes toward science; and 5). the effect that the reflection on their prior experiences had on creating positive visions of their future classrooms.

Text-based Science Education

The only science I remember was out of a text book.
(Angie[2])

Most of the PETs claimed difficulty in recalling school science experiences. At the elementary level eleven of the essays (20%) related mostly negative experiences of science. Many of these were based on the text driven natures of science experienced by the authors. Consider the following excerpts:

> *In the third grade we copied terms out of the back of a book every Friday morning. This continued in the fourth grade. In fifth grade we also did science on Fridays. We would read a chapter and then write all the terms on a piece of paper. (Shelby)*

> *In early elementary I found myself bored by science. All we did was read from an unstimulating textbook. By the time hands -on science began in the 6th grade I already had a bad attitude about it. (Renata)*

Middle school experiences that were related showed some shift toward more experienced or lab-based instruction but lectures and book work also figure predominately in the related experiences (20% of the essays) as a passage from Mary's autobiography illustrates.

> *Thinking back to my first real science class is a nightmare. It was a basic seventh grade science class that everyone had to take. The teacher taught it like that too! ... It was an awful class. The content of the class was maybe one fourth lecture and the other in class readings and book work. I don't even remember doing the typical reports or home projects. (Mary)*

For several of the PETs, the middle school years were the years they identified as when they lost interest in science. Some claim that science became boring and descriptions of the text-based curriculum figure predominantly in this claim.

> *I remember science from middle and high school. It was very boring!!!! It was all textbook with very few experiments. On top of that, most of the experiments were demonstrated by the teacher. For a long time, this turned me off to science because I knew there was more, but was not getting satisfied. (Veronica)*

For Lydia, the boring nature of her science classes was exacerbated by her growing feelings of inadequacy.

> *Unfortunately, my junior high experience wasn't so pleasant. ... I did not understand what my teachers were talking about. I felt dumb and hopeless concerning science. (Lydia)*

This pattern of decreased interest in science in the middle grades has been previously described by Yager & Yager (1985).

At the high school level, six PETs described the didactic nature of their instruction. In these cases, the references were as often to the amount of lectures notes and "Write, write, write until your hands fell off. (Kate)" as they were to the book work of "intense definition copying and drilling. (Liza)" Again, as with Anne, below, "boring" is a term associated with this type of science instruction.

> *Beyond elementary school, I don't have very fond memories*

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2 All names used in this paper are pseudonyms. Other conventions used in the quoted passages include:
... text omitted for brevity
[word] text inserted by author for purposes of clarification or to protect anonymity.
All special emphasis and parenthetical text are from the original documents unless otherwise noted.

of science. It became centered around a text book. This is when I lost interests. The teachers used overhead projectors to give notes and it was extremely boring. I tried to take Chemistry in high school and remember it being mostly book work. I hated it and dropped the class! (Anne)

One student did acknowledge that his high school science teachers had used this approach to help him prepare for college:

I do have to give credit to my high school science teachers , they did prepare me for college, because I got the same, big lecture halls , more lecture.(Mike)

However, only two PETs wrote about text/lecture dominated science instruction that they experienced at the post-secondary level. Then, too, most of the PET's college science courses have been in the elementary science sequence with its emphasis on "hands-on" science.

Hand-On Experiences

In elementary school my science experiences consisted of very little hands-on activities. (Shelby)

Almost every essay recalled some hands-on experience in science, either at the elementary, middle school, high school or post-secondary level schooling and sometimes across all levels. Where hands-on activities were remembered, the PETs had greater and more favorable recall their science experiences. They also tended to go into greater detail when writing about these experiences.

Thirty two PETs (57%) recounted specific episodes or events that they remembered from elementary school. Twelve such experiences included episodes about planting seeds and watching them grow. Other specific events recalled included: field trips and nature walks (6), observations of organisms (6), studying plastic models (5), making collections (5), observing dissected organs or doing dissections (4), pond studies (2), observing celery and food coloring (2) making electric circuits (1) and chemical experiments (1).

Five PETs mentioned science fairs among their elementary memories, mostly in negative terms due to the competitive nature of science and their lack of experiencing science in the classroom. For instance:

We had science fairs starting in the fourth grade, but I always dreaded them because we had to make a project related to science, even though we never had many formal science classes. (Kathy)

For most of the PETs, elementary science could only be recalled as a vague, shadowy experience, seemingly driven by text based instruction. When hands-on activities were recalled, students had more detailed description of these elementary experiences and tend to view these experiences more favorably.

Hands-on experiential learning seems to be as important in the recall of the middle school years as in the primary grades. Students that could recall more hands-on experiences from this period had a better overall attitude towards science and science teaching. In one case, a negative attitude developed during the text based elementary years appeared to be reversed by the active, hands-on instruction experienced in the upper middle school.

In middle school science was taught more often, about three or four times a week. However, by this point in school I was turned off from science completely. In the sixth grade we did no hands-on activities, just reading out of a book and writing terms... In the seventh grade we learned a great deal about physical science. I found it very boring and hated to go to class. We did do many hands-on activities. Because of this I liked my teacher. By the end of the year I realized I did like science, just not reading about it. I also started to enjoy going to class. In the eighth grade we learned about chemistry. This was fun because of all the hands-on. By the beginning of my ninth grade year I loved science and received an A+ all year.(Shelby)

At the middle school level, dissections are the most commonly recalled hands-on experiences. Dissections were mentioned by twelve PETs, with assorted perceptions of the experiences. For some, like Ariel, dissections were positive and interesting experiences.

I remember... ..dissecting a frog. The frog activity is my fondest science memory because it was such a "hyped up" activity. It was the greatest thing about eighth grade. I found it very interesting, especially when my teacher told us the reason we dissect frogs is because frogs resemble the human anatomy the best. I enjoyed finally getting to see in real life what I had learned (memorized) on paper and worksheets for so long. (Ariel)

While for other students, dissections could be physically distressing.

> *In middle school, all I remember about science was being totally grossed out when we had to dissect an earthworm, and actually becoming physically ill when we dissected a frog. The fat bodies inside its stomach looked disgusting. We had macaroni and cheese that day for lunch, and half of the seventh grade threw up. (Lakeisha)*

Other experiences recalled from the middle school years included building artifacts such as barometers, models, solar ovens (6) , doing experiments (4), making collections (4), going on field trips (4), and determining blood type (2).

Memories of dissection also dominate the recall of hands-on science experiences at the high school level with specific referrals in 15 (27%) of the essays. At the high school level, most of the references to dissection are related in a positive manner as shown by the passages for Yvette's and Ken's autobiographies.

> *I love dissecting bugs. In high school I dissected a worm, frog, shark, and pig, needless to say I loved every minute of it. I still get a kick out of conducting chemistry experiments, looking through microscopes, and telescopes. (Yvette)*

> *We dissected a goat heart or something like that in ninth grade biology. I thought that it was neat to see the different chambers of the heart and all of the other things that we had covered in class. I don't think I would like to cut up an animal heart again though because it was sad to think that we were cutting up a dead animal. (Ken)*

Other episodes that merited specific mention include: building of various artifacts (4), observing organisms (2) exploring under the microscope (2), working with Bunsen burners (2), collections (2), field trips (2), and responses of heart rates to different stimuli.

At the post-secondary level, specific hands-on activities were described in only five of the essays. However, "hands-on" experiences as general experiences in the courses that make up the elementary science sequences were cited by 27% of the students. The hands-on approach in these courses seem to be an important component of their science experiences for these students.

> *Now having been in college for four years I have found it impossible to graduate without taking many science classes. All the science classes for elementary teachers promote and teach with hands-on. It is amazing how much information I learn through different hands-on activities without realizing it. It is also nice to be in a class [where] I am having fun and enjoying myself instead of looking at the clock every five minutes to see if class is over yet. (Karly)*

> *The science classes I have had here at [university] have been pretty good for the most part. I enjoyed learning ways to teach kids science using a hands on approach. (Anne).*

It's interesting to note that, although the PETs do list a variety of science activities that they have participated in through their formal education, there is little evidence of actual scientific inquiry, with the exception of a few scattered references to selected science fair projects. In the total sample, there are no references at all to student investigations into scientific questions that are of interest or relevance to them.

Relevancy/Authenticity

> *I never felt a connection to the science in class to the science in my everyday life. (Lydia)*

Interspersed with the stories of text-driven and hands-on experiences in school science, a few students also questioned the connectedness or relevancy of what they were learning. The relevancy questions came up in the recall of elementary experiences for Ariel. By the middle school years it was an important consideration for Lydia and Mary.

> *My middle school teachers extinguished any spark of enthusiasm with their dry technical, and boring classes. I never felt a connection to the science in class to the science in my everyday life. I think my teachers did not emphasize positive attitudes, thinking skills, and interesting science information because they were not enthusiastic about the subject themselves. (Lydia)*

A few students were able to make some connections between school science and the "everyday world," making references such as a better understanding earthquakes after having studied earth science.

At the high school level, the lack of relevance again colored some PETs' memories of science. One PET describe it this way:

> *First class of the day my sophomore year began with chemistry. This is where I really began to dislike science. ... From the first day of class I felt overwhelmed and lost during lectures and certainly during the tests. I remember wondering why do I need to know this, what relevance does it have?. ..Chemistry was my last science class in high school. The thought of having to take any science classes in college scared me to death. (Karly)*

This experience was not unique to Karly, Kay related a similar lack of connection between science instruction and "real life."

> *I didn't understand the connections of science to my life up through high school. What did atoms have to do with me? Important connections were never made. I think one reason is teachers trying to teach the book and only the book (Chapter 1, 2, ... , 18). My teachers never showed any imagination or excitement about science. No one told me why chemistry was important other than, "It will get you into college". (Kay)*

For one PET (Cyndy) the lack of relevancy continued into the university experience. However, for other PETs the science sequence and some of the investigative activities have helped them to discover the relevance of science to their lives which has generally caused a positive shift in attitudes towards science.

> *College brought natural science. I remember a computer program in lab were we tried to abolish the outbreak of Malaria by trial and error. Earth science made sense by explaining why things happen, and helped me to like science. Plate tectonics was a great class. How the earth works is amazing to me. Physics gave me ideas I had never though about before (inertia). Astronomy was more to think and wonder about. Needless to say, I like science now. (Kay)*

> *My attitude towards science has changed in respect to what science is. I use to think that science was all straight facts, dry and simple, without any real exploration. Anything that seemed interesting was not viewed as scientific in my eyes. Now, after many experiences in my career as a student, I see science as something I am able to enjoy. [smiley face] (Tonya)*

For a few students, it was realization that they would soon be responsible for teaching young children science that became an important filter in how they viewed their university science experience.

> *In Chem 101 and earth science I began to relate to science on a different level, and this was because I would be responsible to teach it to my class. My attitude had to change, but not through the lectures; it was mainly through the labs. I was learning activities that I could use in the future, and gaining experiences mostly from what the hands-on projects that were involved in the labs. (Liza)*

Still, in this case of seeing science as something to be taught, there is no reason to assume that "hands-on" science means an investigative or inquiry approach to the subject rather than an activity rich subject. In general, through their writing of hands-on experiences, the PETs do not express the conception of science as a way of knowing or constructing knowledge.

Impacts of Teachers

> *It was my physic instructor Ms. W. who changed my outlook on science. She presented Physics in a way which could only enlighten. I now see the world in ways I had never before. (Delila)*

Teachers were mentioned in 33 (59%) of the essays. The perceived impacts of these people were often related in terms that were coded as strongly positive or strongly negative.

At the elementary level teachers contributed to positive memories of science for four students, for example.

> *In elementary school, I remember looking forward to going to science class. One reason, was that I absolutely adored my science teacher. He was very nice and fatherly to me. So I always gave him my undivided attention. (Lakeisha)*

In contrast, one woman who has a generally positive attitude toward

science, related what to her was a negative experience with one elementary teacher.

> *I do remember asking my third grade teacher, why birds can sit on a wire and not get fried. I remember that so well because her answer was simply "I don't know." and she left it at that. Of course after this type of response I never asked her another science related question. (Yvette)*

Another student also picked up on the value, or lack there of, that her teachers placed on science instruction.

> *After five years of elementary science I did not feel it was an important part of school. I felt the teachers did not enjoy it or value the time spent teaching it. I can remember a couple of boys in my fifth grade class asking why we did so little science. The teacher responded that we just did not have the time to do more. (Shelby)*

Some students correlated their lack of memories of science with their lack of memories of the teachers during this period.

> *I don't remember who my science teachers were, or what they looked like in my elementary school years. That tells me a lot about how important science was to me back then if I can't remember who my instructors were. (Maegan)*

> *It is sad to say but not one of my science teachers left an impression upon my brain. (Delila)*

At the middle school level, PETs also reported the impact of teachers in their recall of science memories. The less desirable images surfaced in nine of the essays and in addition to the perceptions of boring and inept instruction, students also recounted cases of perceived gender bias and sexual harassment.

> *My middle school science experience consisted of one class in seventh grade, required of course. Myself and the rest of the female population spent that year trying to hide our newly developed breasts from a teacher who needed a therapist to say the least. Being as self protection became our number one goal; I don't think I learned a thing about science of any kind. (Karen)*

> *In the 7th grade my teacher was extremely mean. He was into science, but the only people he liked to work with were the "science oriented boys". I asked a question once and got reprimanded for not listening. (Renata)*

Opposed to these less desirable images, fourteen of the essays mentioned positive influences of teachers. One student eloquently described her memory of one particular teacher:

> *I didn't start enjoying science until sixth grade. I had a teacher who the students called 'Doc'. He was the most down to earth and open minded science teacher that I had. Doc involved his students in many experiments. In his class I had opportunities to explore microscopes, chemical reactions, plant growth and development, animal organs and the skeletal system. This science class is the earliest memory of science that I can remember. Probably because Doc was so influential. Until sixth grade science with Doc I thought of science as being boring and something only nerds liked. ..Doc was the teacher that made me realize that my attitude about science is important to succeed. Doc made science fun for the students. If a subject is fun to learn, students will love to explore it deeper. Doc and Mr. C were great teachers, but also made their students think about questions. These teachers gave the information needed and made the students think about questions and answer them. (Shelly)*

Note that in this passage, that the teacher not only made Shelly think about her attitudes and the subject, he also provided opportunities for the students to actively engage in science.

Reminiscences about high school teachers run the spectrum from enthusiastic, knowledgeable teachers to those who taught science in a "dull, boring, monotone." Across the sample, there were 15 passages that made positive references to high school teachers and nine that were more negative. Among the positive attributes are descriptions of teachers that made science interesting and relevant, that thoroughly enjoyed their subject matter, one to the extent of dressing up as Gregor Mendel, and that they respected their students. Some of the most poignant passages illustrate this last point. For example:

> *My senior year I had physiology. This was great! Our instructor did a lot of practical teaching and lessons things*

that I still remember and could replicate today. The most important thing I can learn from this experience and her teaching is that she treated the students with respect. She valued who we were, as well as the questions that we raised in class. She had a very open attitude in class that created a very open atmosphere that lent itself to a lot of learning and exploration. There was never a threat of asking "stupid" questions or a penalty for mistakes in class activities. This open environment helped us to get into the study and really think about what we were being taught. All because she made it relevant. (Mary)

As with the middle school example, in Mary's passage we see a teacher that not only model's appropriate attitudes in the classroom, but also one who structures opportunities for her students to "do" science. This passage stands in sharp relief to some of Renata's negative experiences with her high school teachers.

High school biology was a disaster because the teacher loved to torture students by chasing them with the specimens. ...Then for anatomy and physiology the 7th grade nightmare[teacher] returned. He was worse than ever. But this time he just didn't care. He would plan his basketball schedules. (Renata)

The faculty in the elementary science program were an important element of the collegiate experiences that were cited in twelve of the autobiographies. Tonya represents the sentiments of those that spoke in general terms.

My professors have played a large part in changing my feelings by being enthusiastic in what they teach, and being able to represent science holistically rather than in just one dimension. (Tonya)

Other PETs made mention of individuals and described the way these faculty members conducted their classes. Again, enthusiasm toward the subject matter and connecting the concepts to students lives were frequently mentioned in these descriptions.

Non-Formal Experiences

As for my own personal experiences outside of school I remember a lot. (Colon)

Students that had rich non-formal experiences in science often sustained an interest in, and positive attitude toward, science even when the formal school-based science was a negative experience. For example, Mike feels that most of his interest in science comes form his experiences outside of school...

I look back on my science background and feel science illiterate. I believe that I learned very little in school, and almost all of my good experiences were at home with my chemistry set and microscope. I consider myself lucky though, I still like science and my personal interest in it has at least helped me in taking the first step towards science literacy.(Mike)

..and that these non-formal experiences have sustained his interest in the subject. However, students who lacked these experiences had to depend solely on the way they experienced science in school in forming their attitudes towards the subject..

Thirty five of the students (63%) referred to non-formal or out-of-school experiences in their science autobiographies. The prompt for this part of the essay referred to a personal description of experiences with science, in or out of school, through teachers, friends, parents, museums, magazines, TV, and other sources. Most of the PETs' specific references referred to either people or venues such as museums, camping trips, or the home environment where science was experienced.

Parents had a significant positive effect for thirteen students (23%) in structuring the non-formal science experiences. Yvette is one example of a supportive home environment contributing to a positive attitude towards science.

When I was young, I wanted an inventors set, microscope, or telescope for Christmas, but we were too poor to buy one, so I made do with magnifying glasses from out of cracker jack or cereal boxes. I remember conducting experiments from the things I saw on "Newton's Apple" or repeating things that we did in class at home for my mom, or any of the things in my book that we didn't do in class. My mom watched "Wild Kingdom with my brothers and sister and I faithfully, she also bought us little science and wildlife magazines. I had a rock and bug collection and until this day I still go for nature walks collecting rocks, leaves and interesting things I

find. (Yvette)

This kind of family background is seen played out in Yvette's attitude towards science, "I loved science and still do."

Three students made reference to the importance of recent interactions with children as influencing their attitudes toward science. As one mother related, "My interest in science started when my three children entered school and started to enter the science fair each year (Delila)." The other two PETs made reference to work related experiences with children in child-care facilities and the enjoyment the children had in exploring science activities.

Twelve of the thirty-five students made references to science based television shows: Mr. Wizard, Beakman's World, National Geographic Specials, Wild Kingdom, among others. Some PETs made reference to watching these programs as children with other family members while others have only recently begun tuning in to these programs as a way to experience science.

General Attitudes Towards Science

I personally found science to be great.
(Josh)

If attitude towards science is a consequence of significant personal and professional experiences, then the types of experiences that have been analyzed above contribute to how these students view science and science teaching.

About half of the students started their essays with a general statement about their experiences or attitudes toward science. Seventeen (30%) were distinctly positive and are characterized by statements such as "I have always been interested in science... .. I loved science and still do (Yvette)." "Science has always fascinated me but I have never had time to develop the interest fully (Kent)." Other students were a little more ambivalent, characterized by such statements as "I've never been very good in science, but I've always been fascinated by it (Angie)."

Twelve (21%) of the PETs described a more negative attitude towards science. These statements include: "I really could not tell you what I think science involves just because I do not have a true love for it. (Kathy)." " I don't remember ever liking science, maybe just tolerating it (Angie)" and "I didn't really like science in elementary school, or for that matter; in high school. I felt like it was just something that I had to do, a requirement needed to go on

to the next grade level or to graduate (Maegan)."

All PETs were asked to end their essay by completing the statement, "Science is.... ." Forty-four (79%) completed the statement in a basically positive manner, with answers ranging from "fun" and "exciting" (6 essays) to more descriptive responses such as "...the study of life and the environment (Kristy)." Three students completed the statement in a more ambivalent manner, e.g. "...something I wish I had a better understanding of. (David)" and "...interesting, challenging, frustrating. (Kerri)" Four students completed the statement in a way that was interpreted as a negative view of science, e.g. "... a big cloud of something that is sometimes very boring and confusing. (Cyndy)" and "...a lot like math in my eyes... a technical field with which I have little expertise. (Alexia)"

These statements reveal that there is a wide range of attitudes towards science among the preservice elementary teachers in this study but that most of the PETs are willing to take a positive approach towards science, especially when that attitude is supported by positive experiences in science education. Some of this willingness is explored below in PETs visions of science teaching.

Reflection and Visions of Science Teaching

My recollection of science made me think hard. I realize that I have missed out on a hunk of important information. It is not too late. I can not do that as a teacher and deprive my students of science. I hope to view science more positively. I will go into this class and my future classroom with the right attitude. More teachers should do the same. (Latoya)

Throughout the essays, students commented on the difficulty in recalling specific science experiences. Many concluded that this was due the fact that they seldom "did" science as oppose to read about science. Karen also made a point, that:

I think however, we have failed to make the distinction between remembered experiences and retained knowledge and understanding. (While I do not remember studying space, somewhere along the line someone taught me many little facts I still remember.) (Karen)

Like Latoya above, Tiffany and Sarah also found that the exercise made them think about their experiences in science and how they might affect their future teaching. Tiffany concludes:

I find that somewhere along the way in life I grew to view science very negatively. I am doing my best to try and change that. ...I have negative feelings about science and therefore would tend to ignore it. That is not fair to the children I teach and work with. I want to help them learn to enjoy it. It is important that I change my attitude. I do think that I have made a good start at it so far. (Tiffany)

Although the essay prompt asked the students to reflect on the nature of the science instruction they recalled, it did not explicitly ask the PETs to describe their visions of what science teaching should be or how they would approach the teaching of science in their classrooms. However, this visioning seemed to be a natural conclusion to their reflections for several students. Twenty five students (45%) made statements or claims about what they believe science instruction should look like or how they intend to teach science in their future classrooms. Much of this vision is based on the comparison with their own experiences, as they were recalled during this exercise.

As may be anticipated, a "hands-on" emphasis was strongly envisioned in the classroom by these students.

I know from my elementary school teachers' mistakes that I will use mostly hands-on activities when I begin to teach, rather than memorization and learning of specific terms. (Hillary).

Elementary children need to have actual hands-on to learn and grasp ideas. As soon as I got these opportunities in science I started to enjoy it and actually learn something. I plan to use my own experiences to be a better science teacher and teach whole science with many different ways to learn and grasp new ideas. (Shelby)

I find the things I remember about science are mostly the hands-on topics. (Wow, what an idea...let the kids explore and try things out.) I feel that with some direction and connections to concepts from the teacher, the hands-on approach is effective and memorable for kids. (Kay)

Related to this vision is an emphasis on the process nature of science as evidenced in Casey's statement:

Although I didn't have a very dynamic introduction to the areas of science during my early years, I have formed an appreciation for the goals and ideals of science. ...As a teacher I would like to encourage students to view science as learning, exploring and discovering the world around us, as I do. (Casey)

Making explicit connections or relevance to the "real world" and approaching science more interdisciplinarily were other features of the envisioned classrooms. And finally, the PET's also envisioned introducing an element of fun into their science instruction.

Reflecting on my science education, I realize that I missed out on a lot. My classes could've been more interesting and fun. I want to make my classroom fun so that the children enjoy science and other subjects and don't think of them as difficult and boring. (Anne)

Discussion

So what do science autobiographies tell us about PETs' experiences in science and science education? They reveal that PETs have had a range of experiences in both school-based and non-formal science. Many of experiences can be characterized as positive or desirable experiences in science or as negative, undesirable experiences. On the positive side are many of the active, hands-on experiences that students have had and experiences in science with people, especially teachers and parents, who were enthusiastic and interested about the subject area. On the negative side are experiences characterized by reading text books and completing worksheets, a content approach that is often disconnected from experiences in the everyday world. Also on the negative side are interactions with others, often teachers, who exhibited little interest in the subject or disrespect of the students. Furthermore, these recalled experiences were used by the PETs to justify why they like or do-not-like science, and so, at least in their minds, contributed to their attitudes towards science and science teaching.

In their recall of the pre-college science experiences, the science autobiographies in this study did not differ greatly from the essays described by Young and Kellogg (1993). But in the recall of the experiences in science classes in the professional development program the experiences do differ. At the university where Young and Kellogg conducted their study, the PETs tended to enroll in non-laboratory science courses for the minimum number of

credits (6) required. Their descriptions of the college level science instruction was almost balanced between the number of favorable (n=22) and unfavorable (n=22) comments. In contrast, the comments on college level science courses in this study are more favorable (n= 33) than unfavorable (n= 7). The positive college level experiences by the PETs in this study are largely in reference to the elementary science sequence courses.

The science courses in this elementary science program are especially designed for PETs and emphasize hands-on learning that places the content in the context of teaching science in the elementary school and afford the PETs with the opportunity to carry out simple investigations. The students that reflected on their science course-work in this program had basically positive experiences, some to the extent of reversing prior negative attitudes towards science. This interpretation of the PETs science autobiographies is congruent with Wylo's (1993) quantitative study of 378 PETs enrolled in this program and her findings that the physics and biology courses showed significant net positive attitude changes toward science and science teaching. Wylo's survey of 38 alumni of the program showed that the positive attitudes acquired in the program persists over time.

The autobiographies reveal that, given an opportunity to reflect on their collective science experiences, the PETs can begin to recognize how these experiences have contributed to their feelings about science. Based on their recalled experiences, PETs then begin to envision how they want to approach science instruction in their classrooms, building on their good experiences and avoiding the bad. One of the tasks of professional development programs is to provide the tools and experiences by which these PETs can construct and enact their visions.

Implications for Professional Development

> *My recollection show that the most memorable recollections revolve around hands-on experiences and learning to do by doing. The book work and the skill sheets never are memorable twenty years down the road, but I will never forget planting seeds in third grade. The concepts are important, but whether we are teaching science or anything else we must be sure to give the students a tangible link to something they already know so that what we teach will be remembered when needed. (Ken)*

Throughout their K-12 education, most PETs have "covered" a lot of science content; but they have had little opportunity to "DO" science. Science that was presented as concepts and definitions only served to develop and reinforce negative attitudes towards the subject. While the hands-on experiences were the most memorable experiences for these PETs, many of the "hands-on" activities described by the PETs are simply science related activities and not actual investigations.

Some investigators have postulated that hands-on experiences during professional development may be important for reversing early negative experiences (Pedersen & McCurdy, 1992; Hall, 1992; Ramey-Gassert & Shroyer, 1992). A few researchers have found that specially designed science course work that gives PETs a background in science content through small classes with frequent hands-on *investigations* has a significant effect on attitudes toward science and science teaching (Stefanich & Kelsey, 1989; Westerback, 1982). This would seem to be the case in this study.

The results of these studies suggest that it is the approach to the subject matter that is key in creating positive attitudes toward science and science teaching. These conclusions are also echoed by the findings of Tobias (1990) in her call for instructional changes at the college level. Courses that stress inquiry through hands-on learning and real-world connections go further in fostering a positive attitude towards science than the more traditional content heavy course. The evidence of these PETs experiences does not support the common strategy of increasing content requirements without consideration of the types of sciences experiences embedded in the additional course work. This is congruent with Piel's and Green's (1992) conclusion that in spite of highly visible recommendations for more extensive academic course work, results indicate the impracticality of addressing teacher competence through added course work before appropriate attitude adjustment processes have been planned and implemented.

Other specific attitude adjustment processes are described in the literature. One strategy that has been successfully utilized by Koch (1993) is an "Interview-a-Scientist" assignment that helps PETs to recognize stereotypes about people who do science. A long time ago, Dewey (1933) advocated reflective writing as a forum for addressing attitudes, a strategy that is regaining popularity. Rosenthal (1991) has found certain reflective exercises such as journals, case studies, and role-playing can help students confront their existing conceptions of science as the first step for change. These reflective exercises are then extended by approaching science content in a more process or investigative manner. The science-autobiography assignment from which this study is drawn is one type of reflective exercise that can be used to initiate an attitude adjustment process. As several students reflected in their visions of science teaching, this exercise made them think about their experiences as

students and commit themselves to giving their students better experiences in science.

While calling for reflection by the writers, science autobiographies can also serve the instructor by heightening awareness of students' experiences, fears and interests. Appropriate adjustments in course content may then be enacted to take advantage of this information.

To improve science instruction at the elementary level, preservice elementary teachers need the opportunity to experience sound, authentic, hands-on and inquiry-based science instruction. Such instruction must be incorporated into the professional development program as the majority of PETs do not get this kind of experience during the K-12 years. The experiential instruction should also be coupled with ample opportunities for reflection and practice so that the PETs can begin to incorporate this approach to science education into their own teaching repertoires.

Appendix: ASSIGNMENT 1: SCIENCE AUTOBIOGRAPHY

When you look at your education through the lens of "science," what do you see? Did you have much of it? Did you like it"? Hate it? Did you ever even think about it? A science autobiography is a personal description of your experience with science, **in or out** of school, through teachers, friends, parents, museums, magazines, TV, and other sources.

Frequently, we bring preconceived ideas and beliefs to our science learning and teaching experiences. These are formed by our direct experiences with science, the people we meet who work in science, and the publicity science receives. Please think about your own personal experience with school science, scientists, science in the media, and science teachers. It doesn't matter how limited or extensive your experiences are, only that you describe them.

Relate your earliest memories of school science and your reactions. Write about your experiences with school science up to the present, explaining what you think the study of science involves. What have you grown up to believe about the scientists themselves? Who are they, and what do they do? Close your eyes and visualize a scientist - **draw** a picture of that scientist.

In what ways do your recollections represent whole science? To what extent did your teachers teach science according to our definition? What do you remember about the emphasis given to attitudes, thinking skills, and science information? Why do you think your teachers emphasized (or did not emphasize) each of these parts?

Finally, based solely on your own *personal* experience with science, please complete this sentence: "Science is... ".

Be as candid as possible. This writing-and-thinking exercise will be your first step toward school science *teaching*!

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